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United States
Department of
Agriculture

Forest Service

**Intermountain
Forest and Range
Experiment Station
Ogden, UT 84401**

Research Note
INT-329

May 1983

Seed Transfer Guidelines for Douglas-fir in Western Montana

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Received by: JYB
Indexing Branch

ABSTRACT

Regression techniques accounted for 81 percent of the variance in 3-year height of 54 Douglas-fir populations from western Montana. Seed transfer guidelines are developed from patterns of adaptive variation.

KEYWORDS: seed zones, seed transfer, adaptive variation

Artificial reforestation imposes a risk that planted trees will not be adapted to the environment in which they are planted. To reduce this risk, limits are placed on the geographic and ecologic distance that seeds are moved from their origin. These limits, embodied in seed transfer guidelines, must be based on genetic variation among populations for traits that convey adaptation to natural environments.

The present note presents seed transfer guidelines for Douglas-fir in western Montana. These guidelines were developed from patterns of adaptive variation (Rehfeldt 1982b) according to analytical techniques illustrated for western larch (Rehfeldt 1982a). These techniques assess geographic patterns of variation after effects of elevation are removed. When applied to Douglas-fir populations from western Montana, the approach accounted for 81 percent of the variance in 3-year height of 54 populations. Limits to seed transfer could then be defined as the minimum geographic or elevational interval across which differentiation was detected with a probability of about 80 percent (Rehfeldt 1979).

Adaptive Variation

Adaptive differentiation of Douglas-fir in western Montana is related to physiography and elevation (Rehfeldt 1982). Geographic patterns of genetic variation that are independent of elevation are illustrated in figure 1 by contours of relatively equal performance. A descending numeric value of contours from northwest to southeast is associated with a decreasing innate growth potential and increasing cold hardiness of populations. In addition, growth potential decreases and cold hardiness increases with the elevation of the seed source. These elevational clines, however, are steeper in the west than in the east. Consequently, adaptive variation and seed transfer must be discussed according to two physiographic zones. These zones are separated by the zero contour in figure 1.

Adaptive differentiation of populations arises from natural selection by contrasting environments. Consequently, patterns of genetic variation are closely related to environmental variation. First, as elevations increase, the length of the growing season generally decreases. Consequently, as elevation of the seed origin increases, populations display a decreased growth potential and increased cold hardiness. Second, geographic patterns of genetic variation are closely related to the climatic transitions that occur in western Montana. From northwest to southeast, a climate with a maritime component becomes continental; the frost-free period generally decreases; and precipitation greatly decreases. Patterns of genetic variation that are independent of elevation follow similar patterns (fig. 1). Most notable are relatively large genetic differences (narrow contours) that separate populations across the Bitterroot River Valley in the southwest. Here, annual precipitation decreases from 60 inches at the crest of the Bitterroot Range on the west to 20 inches slightly east of the crest of the Sapphire Mountains. And for the severe environments near the Continental Divide, differentiation in association with both geography and elevation is difficult to detect.

Seed Transfer

Patterns of genetic variation can be used to limit seed transfer by using the following information: (1) contour intervals (fig. 1) are scaled to a value of one-half the geographic distance at which differentiation can be detected (80 percent level), and (2) differences could be detected (80 percent level) between populations separated by 800 feet elevation in the western physiographic province and by 1,600 feet in the eastern province. From this information, either discrete seed zones or floating transfer guidelines can be constructed. In the western physiographic province, discrete seed zones should include two contour bands and 800 feet elevation. Transfers from a single source should be limited to ± 400 feet and ± 1 contour. In the eastern province, seed zones should include two bands and 1,600 feet elevation. Transfer from a single source should be limited to ± 800 feet and ± 1 contour.

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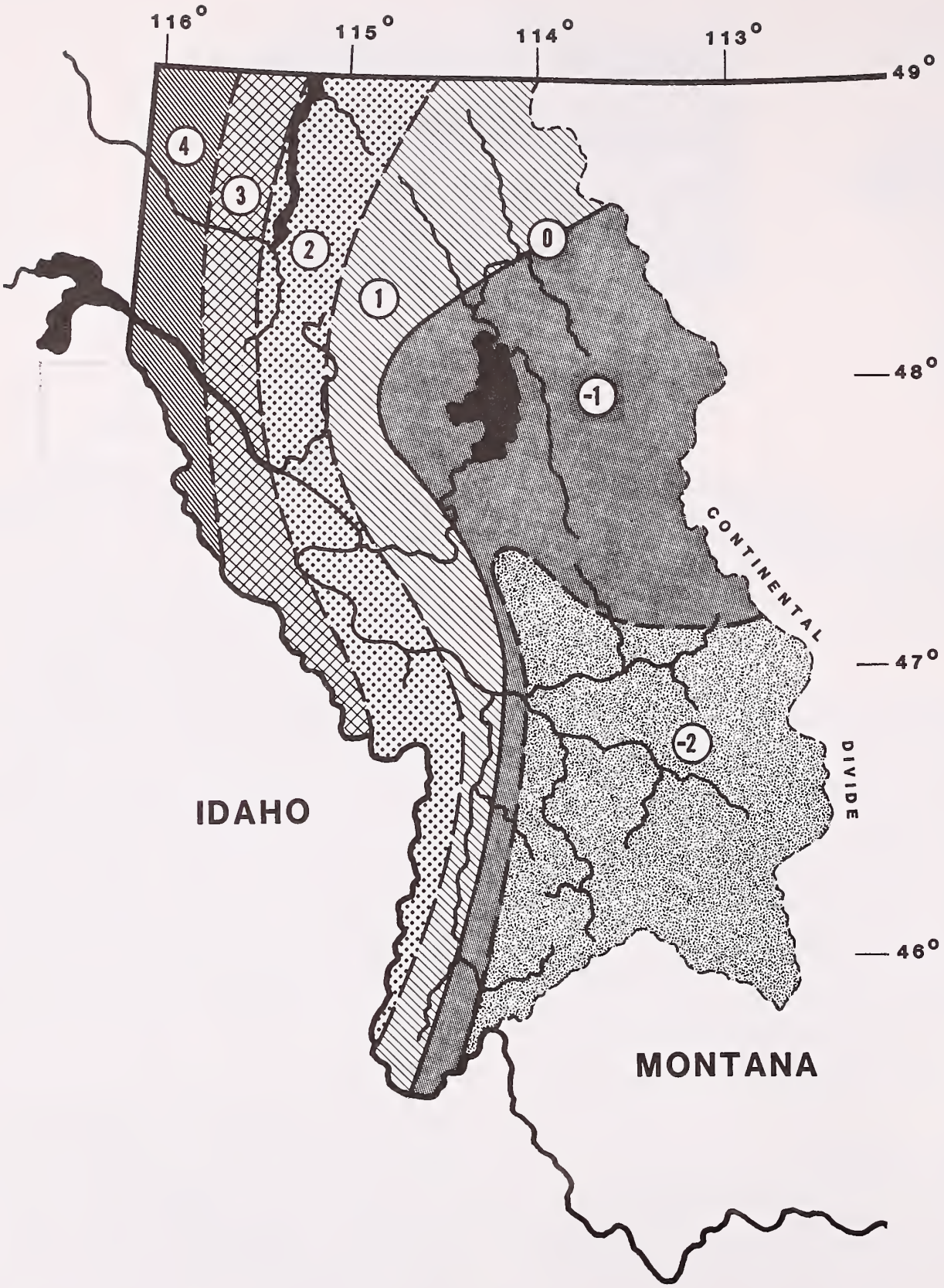

Figure 1.--Geographic patterns of genetic variation among populations of Douglas-fir of western Montana. In the eastern physiographic province (east and southeast of the zero contour), seed transfer from a single source should be limited to ± 1 contour and ± 800 feet elevation. In the west, transfer should be limited to ± 1 contour and ± 400 feet.

Floating transfer guidelines are constructed from the relationship between elevational and geographic differentiation: From the genetic viewpoint, seed transfer across 1 contour is similar to (1) a transfer of 400 feet in elevation within a western band, and (2) a transfer of 800 feet within an eastern band. Thus, seed can be transferred across contours, but each time a contour is crossed, an adjustment must be made in the elevational interval at which that seed is used. When seed is transferred into a band of lower numeric value, the appropriate elevational interval should be lowered by 400 feet for each contour crossed in the western province and by 800 feet for each contour crossed in the eastern province. When seed is transferred into a band of higher numeric value, the interval should be increased by 400 feet in the west and by 800 feet in the east.

For example, if seed is collected from 4,500 feet in band 2, the seed may be used between 4,100 and 4,900 feet (4,500 ± 400) within that band. In band 1 it may be used between 3,700 and 4,500 feet (4,100 ± 400); in band 3, it may be used between 4,500 and 5,300 feet (4,900 ± 400). When seed is transferred between zones, the zero contour should be considered as part of the western zone. In this way, floating transfer guidelines allow a single seed production area to serve several geographic bands.

Small geographic and narrow elevational limits to seed transfer may be impractical or uneconomical administratively. But, expanding the recommended limits of seed transfer increases the risk of losses in productivity in two ways: First, whenever seed adapted to a severe environment is planted in a mild environment, growth potential, as compared to local populations, is reduced. Second, whenever seed from a mild environment is planted in a severe environment, damage from the cold is increased. Estimated losses average 4 percent in 3-year height and about 5 percent in frost injuries for each contour or for each 400 feet (western province) elevation that seed is moved from its origin. There is little doubt, therefore, that even slight relaxation of the recommended limits of seed transfer can greatly alter the productivity of artificial regeneration in western Montana.

The present guidelines were developed from studies of juvenile trees. Because losses in productivity estimated for seedlings likely portend even greater losses before maturity, additional information may demand future alteration of these guidelines

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